Sleep Disturbance is Associated With Cognitive Impairment: a Community Population-based Cross-sectional Study

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Research

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Abstract

Background: Sleep is an important physiological process and conducive to the elimination of brain metabolites and the recovery of brain function. However, the relationship between sleep disturbance and cognitive impairment is not fully been determined.

Methods: This was a community population-based cross-sectional study. A total of 1,461 participants from a village in the suburbs of Xi'an, China were enrolled from January 3 to March 26, 2017. Sleep quality was evaluated using the Pittsburgh sleep quality index (PSQI), and sleep disturbance was defined as a PSQI score >5. Mini-mental state examination (MMSE) was used to assess cognitive function and cognitive impairment was defined as the MMSE score less than cutoff values and meets the diagnostic criteria. Univariate and multivariate analyses were used to analyze the relationships between sleep disturbance and cognitive impairment.

Results: Among 1,461 subjects, 87(5.95%) had cognitive impairment, and 842 (57.63%) had sleep disturbance. In bivariate analysis, cognitive impairment was associated with insomnia (ρ=1.000, P< 0.001), age (ρ=0.172, P<0.001) and educational level (ρ=-0.160, P<0.001). In the binary logistic regression, cognitive impairment was positively associated with the sleep disturbance (OR=1.779, 95%CI=1.055-3.001, P=0.031). In the internal constitution of PSQI, cognitive impairment was positively associated with the sleep interference (OR=1.678; 95%CI=1.029-2.736, P=0.038), and negatively associated with the habitual sleep efficiency (OR=0.115, 95%CI=0.043-0.306, P<0.001). However, people sleep more than 8 hours a day are more likely to suffer from cognitive impairment (OR=3.174, 95%CI=1.570-6.417, P=0.001).

Conclusions: Sleep disturbance is associated with cognitive impairment. However, the causal relationships between sleep disturbances and cognitive impairment are not clear. It needs to be further studied.

Background

Dementia is a general term for loss of memory and other mental abilities, with Alzheimer's disease (AD) is the most common cause of dementia[1]. β-amyloid (Aβ) deposition in the brain is the main pathological change of AD, and the imbalance of production and clearance of Aβ is the main reason[2-4].

Sleep is an important physiological process and conducive to the elimination of brain metabolites and the recovery of brain function[5, 6]. The restorative of brain function during sleep may be due to enhanced clearance of waste products, including Aβ, accumulated in the awake central nervous system[7-10].

The association between sleep and cognitive impairment remains uncertain. The results of studies have been inconsistent. Insomnia was associated with cognitive decline in a cross-sectional study of subjects with an average age of 47 years[11], while studies conducted in older adults had mixed results of sleep and cognition [12-15]. There is no correlation between insomnia and cognition that was proposed through

a cross-sectional study of adults 65 and older in Italy [12]. In contrast, a retrospective cohort study using medical records [13] showed that after three years of follow-up, subjects with healthy sleep were half as likely to develop cognitive impairment as those diagnosed with insomnia and taking hypnotics. Contradictory results were also found in two prospective studies that assessed self-reported insomnia and cognitive decline, with one showed that insomnia is associated with an increased risk of cognitive decline in men and women with depression [14], and another showed no association with cognitive decline or dementia in older men[15]. The inconsistency of results may be partly due to the heterogeneity of research methods and design, especially the differences in insomnia measurement and the diagnosis of cognitive impairment.

Therefore, there is a gap in the existing literature on the relationship between sleep and cognitive impairment. Most studies used a relatively small sample size, including a younger age group, or older participants in a very narrow age group (i.e. 63-68 years), limiting the generality of the results. Existing studies on this subject usually do not include a comprehensive neuropsychological assessment, mainly using the patient's subjective sleep complaint.

In the present study, we investigated the relationships between sleep disturbance and cognitive impairment in a community population.

Methods

Study Design and Population

Participants were enrolled from a cross-sectional study conducted in a village in Xi'an, China, from January 3 to March 26, 2017. The village was randomly selected by the method of cluster sampling, and its population composition as well as the villagers' lifestyles were similar to that of rural areas of Xi'an. The inclusion criteria were 1) over 40 years old, 2) willing to join, and 3) informed consent. The exclusion criteria were 1) suffered from cerebrovascular diseases and other neurological conditions that may influence cognitive function (such as epilepsy, central nervous system infections, Parkinsonism, intracranial trauma, or surgery). 2) failed to complete the Pittsburgh sleep quality index (PSQI) and the mini-mental state examination (MMSE) or not finishing clinical investigation, 3) had incomplete data.

The Medical Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University approved this study, and informed consent was obtained from every participant. The enrolled subjects were first given a face-to-face structured interview for health status, medical history, and physical examination at the committee office or their own home if they had difficulties going to the office. Meanwhile, fasting blood samples of individuals were collected in the morning 9 am to 11 am.

Cognitive assessment

All of the subjects were carried out a cognitive screening using the Mini-Mental State Examination (MMSE). The cutoff values were as follows:≤17 for subjects with illiteracy, ≤20 for primary school educated subjects, and≤24 for those educated at the junior high school level or above. Participant with

MMSE score≤cutoff values underwent the 2nd phase cognitive examinations, including the Fuld Object Memory Evaluation test, Rapid Verbal Retrieval test, Trail-Making test, Digit Span test, and Block Design test. The diagnosis of cognitive impairment was determined according to the diagnostic criteria for dementia [16] and MCI [17] by a senior neurologist.

Assesses of sleep quality

All subjects were asked to assess their sleep quality over a 1-month time interval by independently completing the Pittsburgh sleep quality index (PSQI). PSQI is a self-rated questionnaire consisting of 7 parts（subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep interference, use of sleeping medication, and daytime dysfunction）and is obtained through 19 independent questions[18]. Sleep disturbance was defined as a PSQI score >5. Further, PSQI score 6-10 defined as mild sleep disturbance and PSQI score 11-20 defined as moderate and severe.

Other covariates

Participant self-reported sociodemographic variables (age, gender and education level) and specific clinical factors (smoking and/or alcohol status) and disease variables (diabetes, hypertension, hyperlipidemia, anxiety and depression). Participants also had a neurological examination, a systemic physical examination, blood biochemical examination. Body mass index (BMI) was calculated as weight divided by height squared and divided into four levels: underweight (BMI, <18.5), normal weight (BMI, 18.5-23.9), overweight (BMI, 24-27.9), obese (BMI>28). Smokers are defined as those who have smoked continuously or accumulated for 6 months or more during their lifetime [19]. Drinking is defined as exceeding a certain daily drinking amount (e.g. 3 standard cups per day) or drinking amount per time (e.g. 5 standard cups per time, at least once a week). The diagnoses of diabetes, hypertension, hyperlipidemia, anxiety and depression were based on self-reported disease history or taking anti-hypertensive, anti-diabetic, lipid-lowering drugs, anti-depressants or anti-anxiety medications, or newly diagnosed according to guidelines [20, 21]

Statistical Analysis

Histogram and normal probability plot (P-P) of standardized residual, and residual plots were performed to ensure the normality and homogeneity of residuals. Comparison of approximately normal continuous variables was conducted by independent *t*-test and mean (standard deviation). Mann-Whitney U test and median (interquartile range) were employed to compare the difference of the abnormal distributed continuous variables, and χ^2 test and number (percentage) was used to compare categorical variables.

The relationship between cognitive impairment and sleep disturbance were analyzed by simple Spearman's correlation analysis first. Then, bivariate Logistic regression analysis was employed to adjust the confounding factors. The histogram was used to compare the prevalence of cognitive impairment among people with different sleep quality. Next, using the same method to analyze the relationship between specific components of sleep disorder and cognitive impairment. All the analyses are two-sided.

P < 0.05 was statistically significant. All statistical analyses were carried out using SPSS (IBM, USA,22.0 version). All of the graphs were drawn in GraphPad Prism (Texas,8.3.0 version).

Results

The Characteristicsof Study population

There were 1,821 villagers who met inclusion criteria. Of these, 131 had a cerebrovascular disease or other neurological conditions, 143 did not complete questionnaires, 86 were excluded because of limited data. Finally, 1,461 were included in the analysis (**Figure 1**).

Among 1,461 participants, 87(5.95%) had cognitive impairment and 842(57.63%) had sleep disturbance. **Table 1** lists the clinical characteristics of the population. Compared with normal sleep group, the sleep disturbance group were older (*P*<0.001), had more female subjects (*P*=0.002), shorter years of education (*P*<0.001), higher rates of drinking (*P*=0.027), and more likely to suffer from anxiety and depression (*P*=0.001) and hypertension (*P*<0.001), but lower rates of smoking (*P*=0.015).

Cognitive impairment in sleep disturbance group and normal sleep group

The prevalence of cognitive impairment in sleep disturbance group was obviously higher than that in the normal sleep group (7.84% vs. 3.39%, *P*<0.001). Further, as the degree of sleep disturbance increases, the prevalence of cognitive impairment increases accordingly (**Figure 2**). Spearman rank correlation analysis showed that the degree of sleep disturbance is positively correlated with the prevalence of cognitive impairment (ρ=0.102, *P*< 0.001).

The factors Associated with cognitive impairment

According to the cognition states, the total population is divided into normal cognition group and cognitive impairment group. Compared with normal cognition group, the cognitive impairment group were older (*P*<0.001), more likely to suffer from hypertension (*P*=0.020), but shorter years of education (*P*<0.001), lower BMI (*P*=0.018) and have less smoking problems (*P*=0.012). Above all, the prevalence of sleep disturbance in the cognitive impairment group was obviously higher than that in the normal sleep group (75.86% vs. 56.48%, *P*<0.001) (**Table 2**).

Multiple analysis of factors associated with Cognitive Impairment.

In order to clarify the variables related to cognitive impairment, a Spearman binary correlation analysis was conducted. Cognitive impairment was positively correlated with sleep disturbance (*ρ*=1.000, *P*<0.001), drinking (*ρ*=0.058, *P*=0.027), hypertension (*ρ*=0.108, *P*<0.001), but negatively with education level (*ρ*=-0.160, *P*<0.001), gender (*ρ*=-0.082, *P*<0.002), smoking (*ρ*=-0.059, *P*=0.025) and anxiety and depression (*ρ*=-0.089, *P*=0.001) (Table 3). Besides, greater cognitive impairment was reported by patients older than 60 years (*ρ*=0.172, *P*<0.001) compared with those younger than 60 years.

To eliminate the influence of covariates, binary logistic regression analysis was performed. Cognitive impairment was positively associated with sleep disturbance (OR=1.779, 95%CI=1.055-3.001, P=0.031) and age>60 (OR=2.013, 95%CI=1.167-3.472, P=0.012), but negatively associated with smoking (OR=0.455, 95%CI=0.208-0.992, P=0.048). Besides, participants with elementary school education(OR=0.263, 95%CI=0.137-0.503, P<0.001) and junior high school and above education(OR=0.247, 95%CI=0.085-0.721, P=0.011) were less likely to have cognitive impairment than those who are illiterate (**Table 4**).

The Relationship Between Sleep disturbance and Cognitive Impairment.

Mann-Whitney U test and median (quartile) was employed to compare the difference of components of sleep between cognitive impairment group and cognitive impairment group. Compared to normal cognitive group, the cognitive impairment group had shorter sleep duration (6.0 hours vs. 6.5 hours, P=0.010), lower habitual sleep efficiency (66.67% vs. 78.95%, P<0.001) and more sleep interference (6.0 points vs. 5.0 points, P<0.001) (**Table 5**).

Spearman binary correlation analysis was used to explore the correlation between cognition and components of sleep. As shown in the Table 6, cognitive impairment was positively correlated with sleep interference (ρ=0.110, P<0.001), but negatively with Sleep duration (ρ=-0.067, P=0.010) and Habitual sleep efficiency (ρ=-0.132, P<0.001)

To further exclude the interference of other factors, the internal composition of sleep and other basic variables were included in the binary logistic regression. As shown in **Figure 3**, cognitive impairment was still positively associated with the sleep interference (OR=1.678, 95%CI=1.029-2.736, P=0.038), and negatively associated with the habitual sleep efficiency (OR=0.115, 95%CI=0.043-0.306, P<0.001). In order to more accurately evaluate the effect of actual sleep duration on cognitive impairment, different sleep duration was included in the regression analysis in turn, and it was found that cognitive impairment was more likely to occur if the sleep duration was more than eight hours a day (OR=3.174, 95%CI=1.570-6.417, P=0.001) (**Figure 3**).

Discussion

In this population-based cross-sectional study, we used MMSE to assess cognitive function, and used PSQI to evaluate sleep quality in more than 1,400 subjects. We found that cognitive impairment was positively associated with the sleep disturbance, and negatively associated with the habitual sleep efficiency. People who have sleep more than 8 hours a day are more likely to suffer from cognitive impairment. These indicated that sleep disturbance are associated with cognitive impairment which are consistent with previous studies [22].

Many studies have focused on the relationships between sleep disturbance and cognitive impairment, but the conclusion is not determined. Compared to previous studies, the present study is a large samples community population-based study. We used a method of random cluster sampling to selected villages,

and the population composition was similar to that in the rural areas of Xi'an which make the sample reasonably represents the rural areas of Xi'an. The diagnosis of cognitive impairment was made according to MMSE score first, and then the subjects underwent the 2nd phase cognitive examinations, to make sure the diagnosis of cognitive impairment is reliable. Meanwhile, we used PSQI to assess sleep quality over a 1-month time interval. PQSI is a self-rated questionnaire, which assesses sleep quality and disturbances. The scale consists of 7 parts（subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction）and is obtained through 19 independent questions. PSQI score＞5 yielded a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa = 0.75, $P < 0.001$) for sleep disturbance [18]. Seven indicators have proven that PSQI to be a reliable and effective measure of insomnia, with a Cronbach's α of 0.83 [18]. These assure that our results are reliable and convincing.

The reason of cognitive impairment did not determine. Considering the subjects who had cerebrovascular diseases and other neurological conditions that may influence cognitive function (such as epilepsy, central nervous system infections, Parkinsonism, intracranial trauma, or surgery) already were excluded, we think that the cognitive impairment might due to AD.

Although the exact mechanism of sleep disturbance involves in cognitive impairment has not been fully determined. A growing number of studies have found that sleep disorders may lead to cognitive impairment and accelerate AD pathology, including increased Aβ deposition in the brain [23]. Our recent studies also showed that sleep deprivation induced peripheral Aβ transport dysfunction in young adults [24], and Aβ accumulation in the brain in rats [25]. The underlying mechanism may involve in the oxidative stress in the brain and plasma[26, 27].

Limitations

However, due to cross-sectional design, which prevents us from clarifying any causal and temporal relationship between cognitive impairment and sleep disturbance. We cannot certify that sleep disturbance is a risk factor for cognitive impairment. Because, many patients with AD and other dementia frequently have sleep disturbance[28-33]. A follow-up study to detect the changes of cognition function is necessary.

In addition, we did not use any sleep monitoring devices to objectively assess sleep conditions, such as polysomnography and activity tracking, but relied on self-reporting, which may cause recall bias. However, studies have shown that the use of polysomnography to record the results of sleep in the elderly[34] is consistent with the subjective reports. In addition, polysomnography monitors are expensive and labor-intensive, which not suitable for using in a large-sample epidemiological studies.

Conclusion

In conclusion, this large-scale survey of 1,461 villagers found that sleep disturbance is associated with cognitive impairment, especially for sleep duration, sleep interference and habitual sleep efficiency.

However, the causal relationships between sleep disturbances and cognitive impairment are not clear, which need to be further studied.

Abbreviations

PSQI: Pittsburgh sleep quality index

MMSE: Mini-mental state examination

OR: Odds ratio

AD: Alzheimer's disease

Aβ: β-amyloid

BMI: Body mass index

P-P: Histogram and normal probability plot

SD: standard deviation

Declarations

Ethics approval and consent to participate

The Medical Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University approved this study, and informed consent was obtained from every participant.

Consent for publication

Not applicable

Availability of data and materials

Anonymized datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

FG participated in the study design, performed the statistical analysis, and drafted the manuscript. SW, LJD, YG, LG, SHS, CC, KH and JW participated in the clinical evaluation, design of the study and carried out the neurocognitive and sleep evaluation and scoring. JYW participated in the clinical evaluation. QMQ participated in concept formation, study design, and manuscript drafting, revision, and final approval. All authors read and approved the final manuscript.

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Tables

Characteristics	Total (n=1461)	Sleep disturbance group (n=842)	Normal Sleep group (n=619)	*P* value
Age, years	57.14(9.60)	58.71(9.68)	55.02(9.08)	<0.001
60, n(%)	541(36.95)	364(43.23)	177(28.59)	<0.001
Male, n(%)	592(40.46)	312(37.05)	280(45.23)	0.002
Education, years	6.72(6.83)	6.18(6.57)	7.48(7.12)	<0.001
Drink, n(%)	471(32.19)	291 (34.56)	180(29.10)	0.027
Smoke, n(%)	448(30.62)	237(28.14)	211(34.08)	0.015
BMI, kg/m^2	25.24(3.66)	25.25(4.03)	25.23(3.10)	0.095
Anxiety and depression, n(%)	61(4.17)	48(5.70)	13(2.10)	0.001
hyperlipidemia, n(%)	288(19.69)	168(19.95)	120(19.39)	0.788
Diabetes, n(%)	162(11.07)	90 (10.69)	72(11.63)	0.613
Hypertension, n(%)	358(24.47)	240(28.50)	118(19.07)	<0.001
Cognitive impairment, n(%)	87(5.95)	66(7.84)	21(3.39)	<0.001

Table 1. Characteristics of the total study population.

Unpaired Student's *t*-test and mean±SD were employed to compare the difference of the approximately normal distributed continuous variables between sleep disturbance group and normal sleep group, Chi square and number (percentage) were used for categorical variables. Data are mean (SD) or number (percentage). The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria. PSQI score5 are defined as sleep disturbance. BMI, body mass index.

Table 2. Comparison of cognitive impairment group and normal cognition group

Characteristics	Cognitive impairment group (n=87)	Normal cognition group (n=1374)	P value
Age, years	66.76(9.74)	56.54(9.27)	<0.001
>60, n(%)	61(70.11)	480(34.93)	<0.001
Male, n(%)	29(33.33)	563(41.00)	0.097
Education, years	2.12 (3.12)	7.02(6.90)	<0.001
Drink, n(%)	29(33.33)	442(32.17)	0.453
Smoking, n(%)	17(19.51)	431(31.36)	0.012
BMI, kg/m^2	24.42(3.25)	25.30(3.68)	0.018
Anxiety and depression, n(%)	2(2.30)	59(4.30)	0.282
Hyperlipidemia, n(%)	15(17.24)	273(19.87)	0.331
Diabetes, n(%)	6(6.90)	156(11.35)	0.131
Hypertension, n(%)	30(34.48)	328(23.87)	0.020
Sleep disturbance, n(%)	66(75.86)	776(56.48)	<0.001

Unpaired Student's *t*-test and mean±SD were employed to compare the difference of the approximately normal distributed continuous variables between cognition impairment group and normal cognition group, Chi square and number (percentage) were used for categorical variables. Data are mean (SD) or number (percentage). The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria. PSQI score>5 are defined as sleep disturbance. BMI, body mass index.

Table 3. Correlation analysis between cognitive impairment and clinical basic variables

Variables	Cognition impairment	
	ρ	P
Sleep disturbance	1.000	<0.001
Age>60	0.172	<0.001
Gender	-0.082	0.002
Education level	-0.160	<0.001
Drinking	0.058	0.027
Smoking	-0.059	0.025
BMI	-0.015	0.566
Anxiety and depression	-0.089	0.001
hyperlipidemia	0.007	0.788
Diabetes	-0.015	0.571
Hypertension	0.108	<0.001

Spearman correlation analysis was used to test the existence of correlation between cognition impairment, sleep disturbance, age, gender, education level, drink, Smoke, BMI, anxiety and depression, hyperlipidemia, diabetes and hypertension. The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria. PSQI score>5 are defined as sleep disturbance. BMI, body mass index.

Table 4. Binary logistic regression of cognitive impairment and clinical basic variables

Independent variables	P value	OR (95% CI)
Age>60	0.012	2.013(1.167, 3.472)
Gender: male	0.264	1.477(0.745, 2.930)
Elementary school	<0.001	0.263(0.137, 0.503)
Junior High school and above	0.011	0.247(0.085, 0.721)
Drinking	0.918	0.973(0.572, 1.653)
Smoking	0.048	0.455(0.208, 0.992)
BMI	0.056	0.934(0.872, 1.002)
Anxiety and depression	0.245	0.423(0.099, 1.805)
Hyperlipidemia	0.891	0.959(0.522, 1.760)
Diabetes	0.384	0.678(0.282, 1.627)
Hypertension	0.377	1.252(0.760, 2.063)
Sleep disturbance	0.031	1.779(1.055, 3.001)

Logistic regression analyses of participant characteristics associated with the cognitive impairment. The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria. PSQI score>5 are defined as sleep disturbance. BMI, body mass index.

Sleeping status	Cognitive impairment group	Normal cognition group	P value
Subjective sleep quality	2.00(2.00,2.00)	2.00(2.00,2.00)	0.595
Sleep latency, min	30.00(10.00,60.00)	30.00(10.00,30.00)	0.959
Sleep duration, hour	6.00(4.50,7.50)	6.50(5.50,7.50)	0.010
Habitual sleep efficiency, %	66.67 (47.62,80.00)	78.95 (64.71,90.00)	<0.001
Sleep interference	6.00(4.00,10.00)	5.00(3.00,8.00)	<0.001
Use of sleeping medication	1.00(1.00,1.00)	1.00(1.00,1.00)	0.204
Daytime dysfunction	0.00(0.00,3.00)	0.00(0.00,2.00)	0.160
Total scores	8.00(6.00,11.00)	6.00(4.00,9.00)	<0.001

Table 5. Comparison of sleeping status in cognitive impairment group and normal cognition group.

Mann-Whitney U test and median (quartile) were employed to compare the difference of the abnormal distributed continuous variables between cognitive impairment and normal cognition. The cognitive

impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria.

Table 6. Correlation analysis of cognition impairment and internal components of sleep disturbance.

Sleeping status	Cognition impairment	
	ρ	P
Subjective sleep quality	0.014	0.596
Sleep latency, min	0.001	0.959
Sleep duration, hour	-0.067	0.010
Habitual sleep efficiency, %	-0.132	<0.001
Sleep interference	0.110	<0.001
Use of sleeping medication	0.033	0.204
Daytime dysfunction	0.037	0.160
Total scores	0.101	<0.001

Spearman correlation analysis was used to test the existence of correlation between cognition impairment, subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep interference, use of sleeping medication and daytime dysfunction. The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria.

Figures

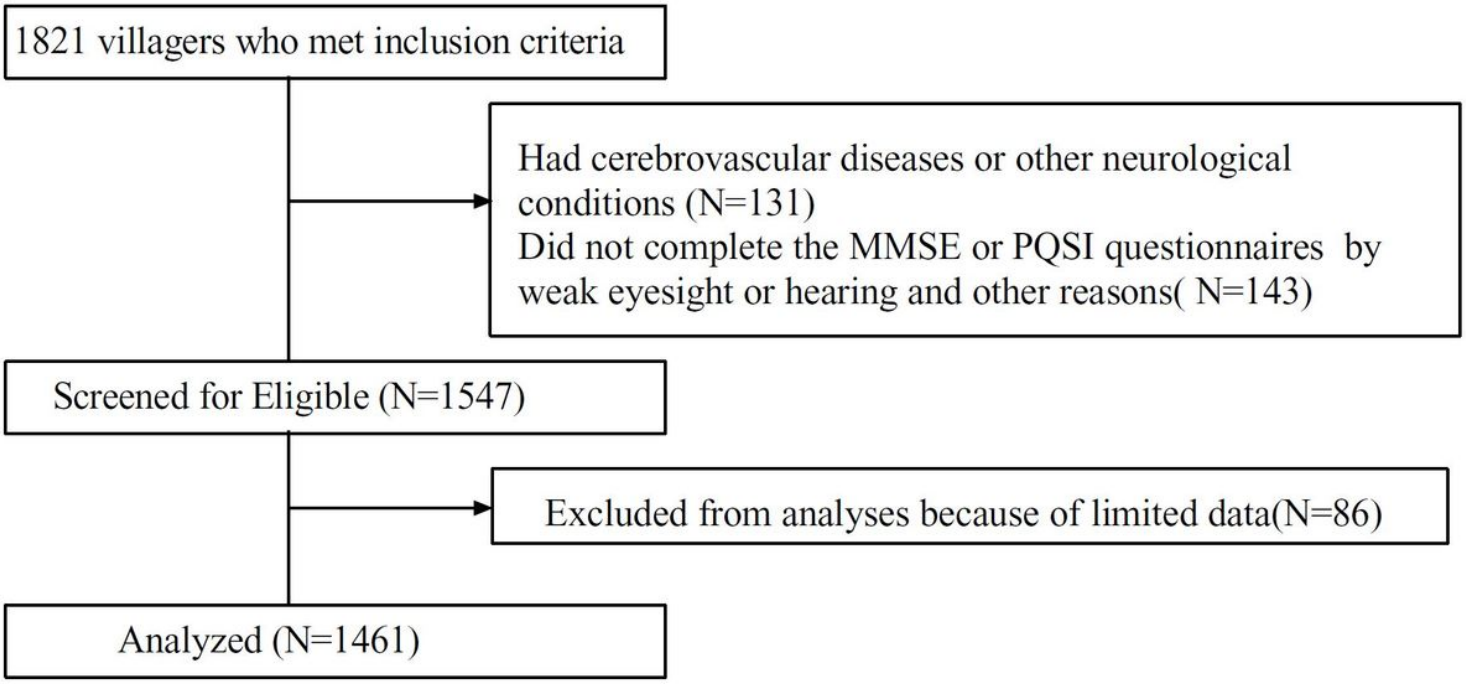

Figure 1

Flow chart of participant selection.

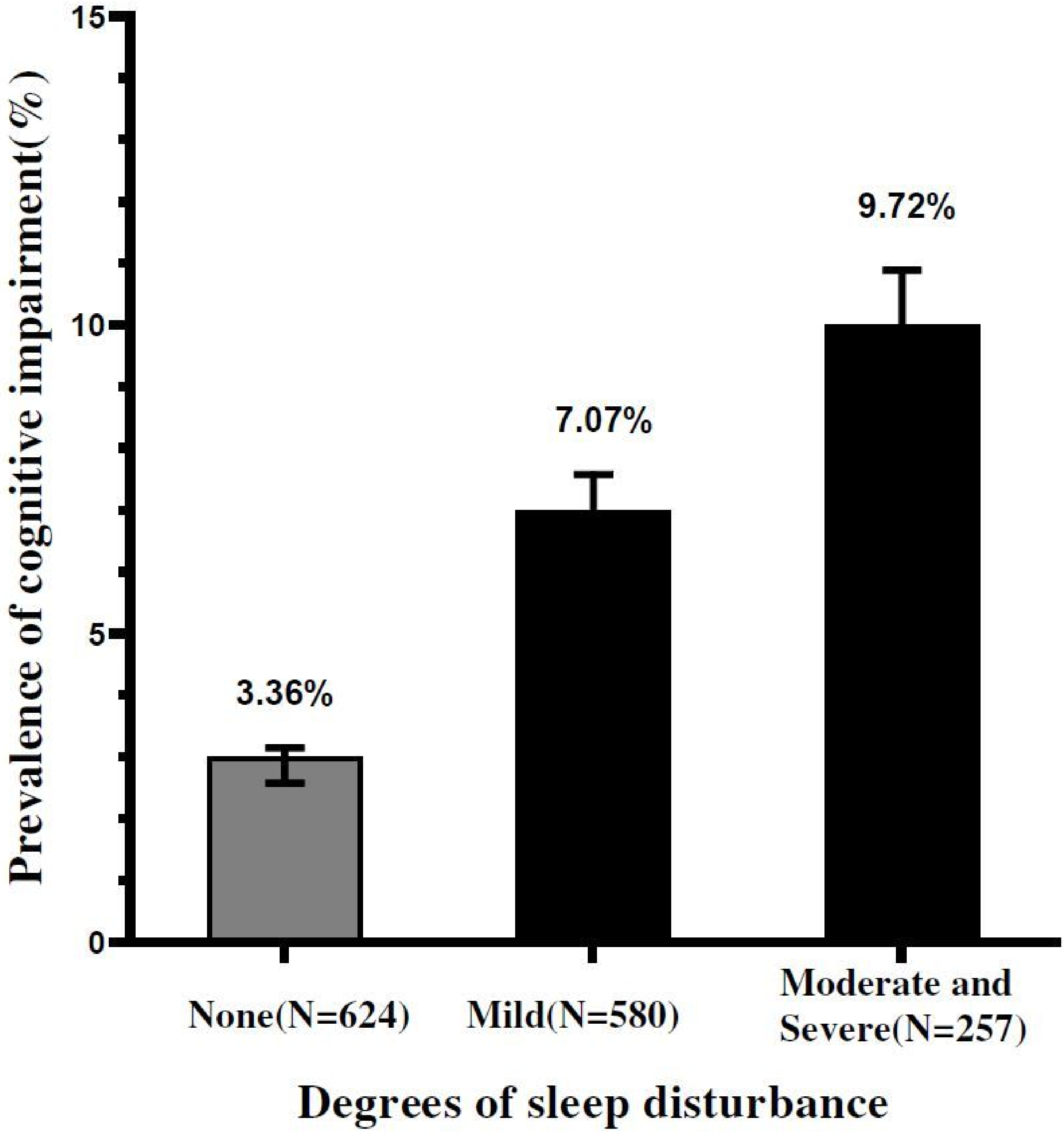

Figure 2

The prevalence of cognitive impairment in people with different degrees of sleep disturbance. The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria. PSQI score ≤5 are defined as no sleep disturbance, 6-10 as mild sleep disturbance, 11-20 as moderate and severe sleep disturbance.

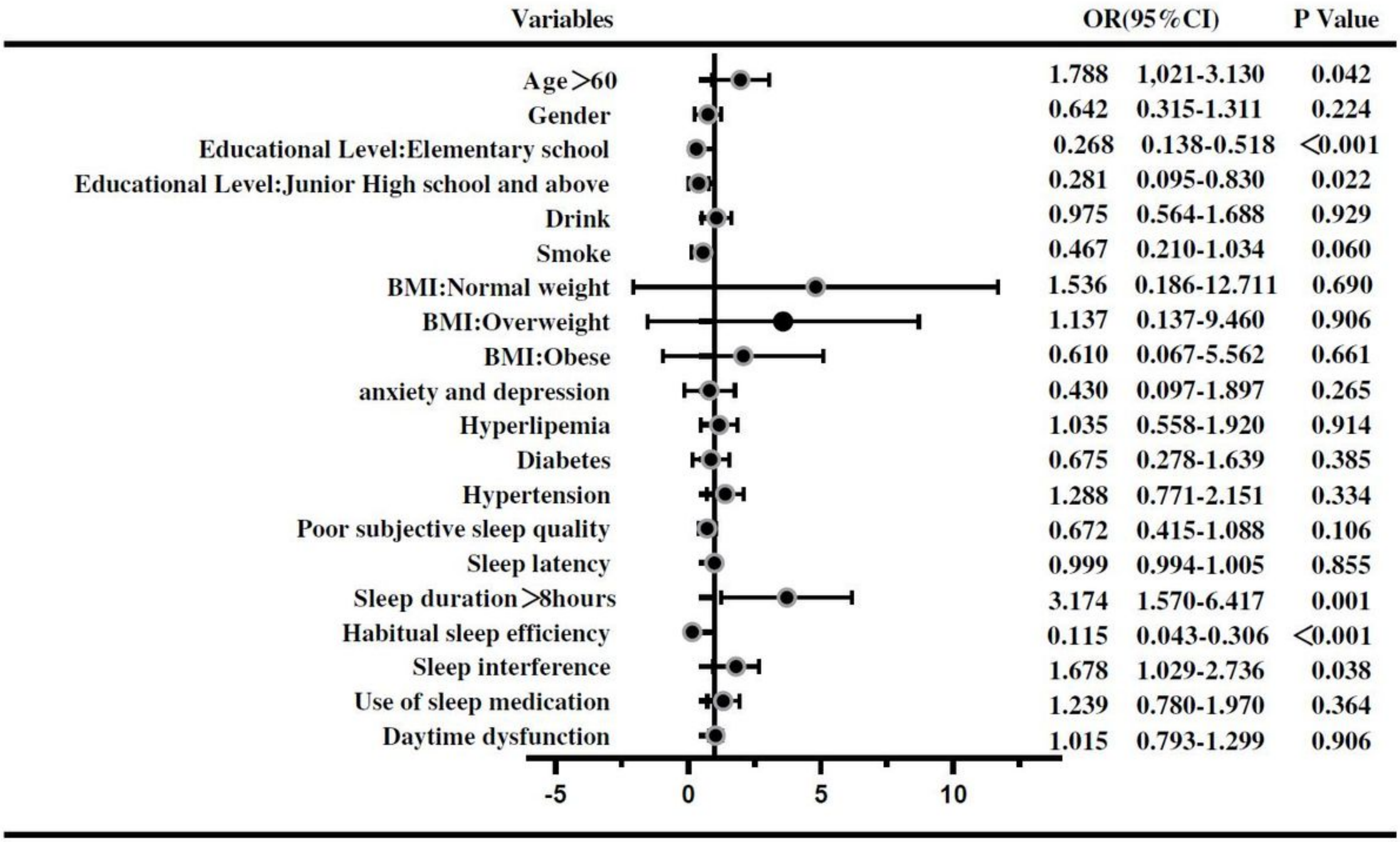

Figure 3

Logistic regression analyses of participant characteristics associated with the cognitive impairment. The cognitive impairment defines as MMSE score below the cutoff values: ≤17 for illiterate, ≤20 for primary school educated, and ≤24 for junior high school educated or above and meets the diagnostic criteria. BMI, body mass index.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Sleepdisturbanceisassociatedwithcognitiveimpairment.pdf